DISCUSSION OF INNOVATIVE ESSENCE OF THE INVENTION

1. The innovative essence of the invention consists in **applying a specific innovative form** (see more detailed description below) of the four-link flat or spatial (more precisely spherical) mechanism (i.e. flat or spherical four bar linkage) to vehicle suspension to get a required progressive damping characteristic (more precisely a required differentiable dependence of a spring on a vehicle wheel flex) and, at the same time, uniquely compact and robust suspension's structure.

   Thus the principal distinctive technical feature of my suspension system is **specific innovative form of** (at least one) **four-link mechanism that it comprises.**

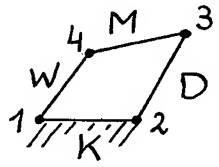
   This principal distinctive feature is disclosed in generic claims 1 (canceled) and 11 (new) and 18 (new) and is readable upon all the species shown in figures 1-7.

   In particular, my inventive concept is obviously not just including of an eccentric connection in a vehicle suspension (which would be trivial!).

2. In order to make my invention clear I discuss my mechanisms and my concept of applying them in vehicle suspension in more detail.

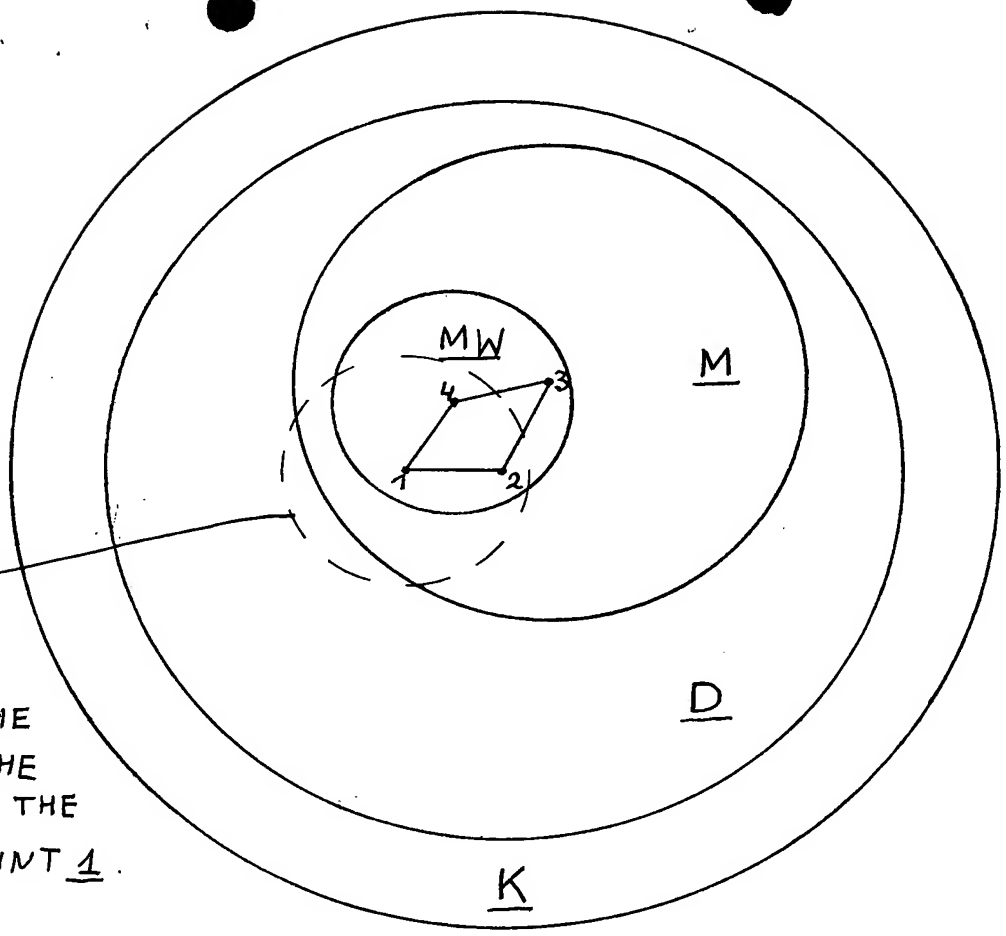
   How to get flat mechanisms as used in my vehicle suspension (see also the photos attached)?

   a. I start with the ordinary four bar linkage, the four links of which are labeled K, M, W, D:



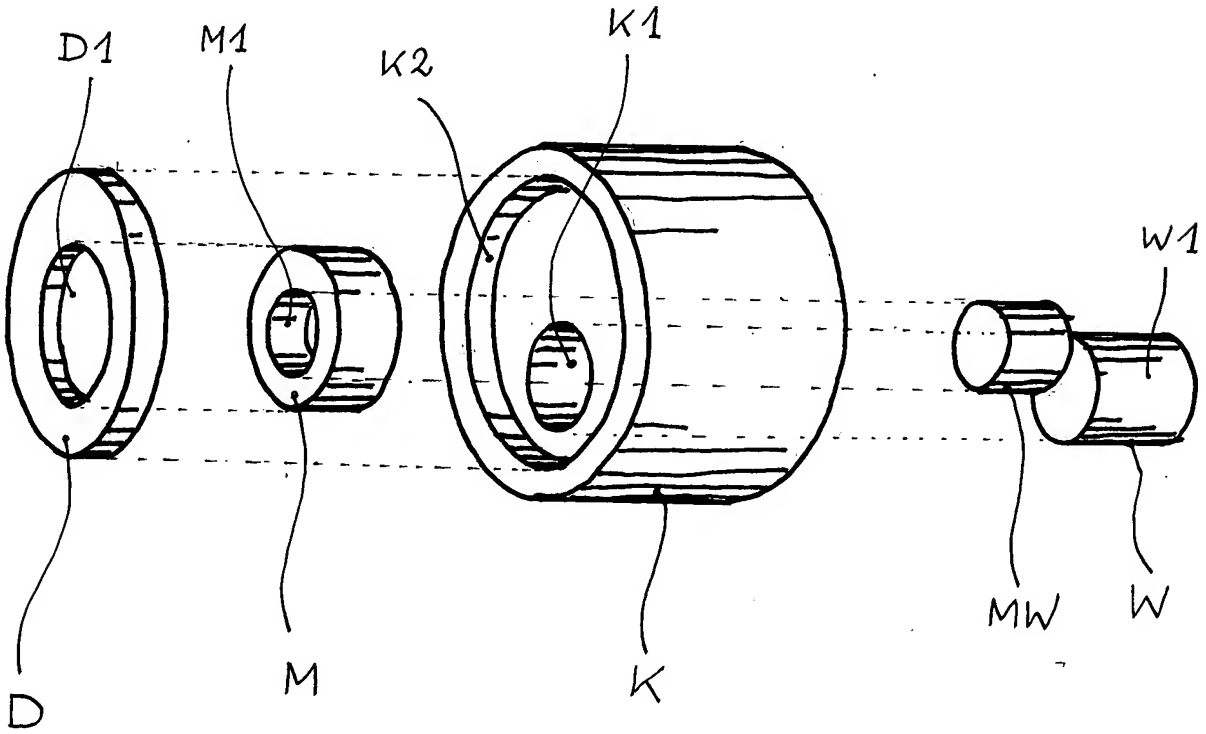
   b. Next I give the links of the mechanism the form of eccentric:

   In the picture below broken line indicates the main pin of the "shaft" W with the center at the point 1, MW is the eccentric fastened to the shaft W with the center at the point 4, the intermediate eccentric M has the center at the point 3 and the disc D has the center at the point 2.



BROKEN LINE INDICATES THE MAIN PIN OF THE "SHAFT" W WITH THE CENTER AT POINT 1.

c. Expanded view of the mechanism obtained in this way is as follows:



Thus this mechanism comprises four links: "body" K, "shaft" W, "disc" D and "intermediate eccentric" M. (The names "body", "shaft", "disc" and "intermediate eccentric" are provisional; what is essential is that at least three of them, namely M, W and D, assume general form of an eccentric. In particular the shaft W is fitted with an eccentric MW, which forms with said shaft W a unique whole). The shaft W is coupled rotationally, via the eccentric MW, with the intermediate eccentric M, the intermediate eccentric M is coupled rotationally with the disc D, and both the shaft W and the disc D pivot directly in the body K. More precisely, main pivot W1 of the shaft W pivots in "small" circular bore chamber K1 placed in the body K, disc D pivots in "large" circular bore chamber K2 placed in the body K, the eccentric MW of the shaft W pivots in the eccentric circular bore chamber M1 placed in the intermediate eccentric M, and the intermediate eccentric M pivots in the eccentric circular bore chamber D1 placed in the disc D. Axes of rotation of all the kinetic couples are parallel to each other precisely as described in the specific part of the claim 12 (new).

This is the principal form of my four-link mechanisms. Links of said mechanism assume the form of eccentric as declared in the distinctive part of generic claims 11 (new) and 18 (new). Of course links of said mechanisms can assume various specific shapes, retaining however the general form of eccentric and therefore having the distinctive feature ("...three of said links are made in the form of an eccentric...", see claim 11 (new)) described in the distinctive part of generic claims 11 (new) and 18 (new). Any of the species shown in figures 1-7 comprise a mechanism of this type.

Kinetics of this mechanism (which strongly depends on the mechanism geometry) is strongly non-linear, and when a vehicle wheel is coupled with one link of the mechanism, a spring is coupled with another link, and the whole mechanism is fastened to the vehicle frame through yet another link, we get the required non-linear (preferably progressive) damping characteristic of the suspension.

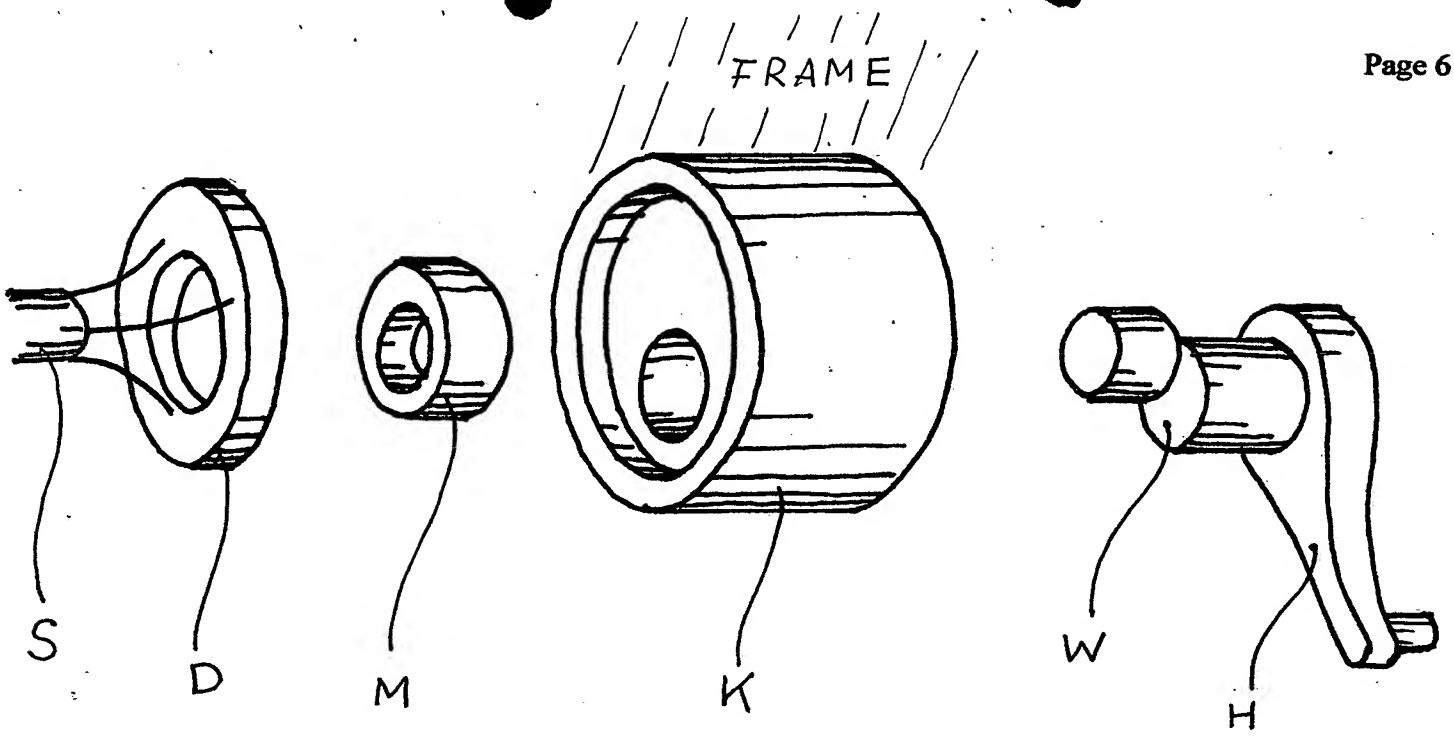
The mechanism is extraordinarily compact and robust in fact this is the strongest mechanism (not reducing to kinetic couple) in existence.

How do the mechanisms as described above enter my vehicle suspension system?

Now I show how the mechanisms as described above enter my vehicle suspension system and provide all the species shown in figures 1-4 and 6 (all these comprise a flat mechanism and are covered by the generic (independent) claim 11 (new).

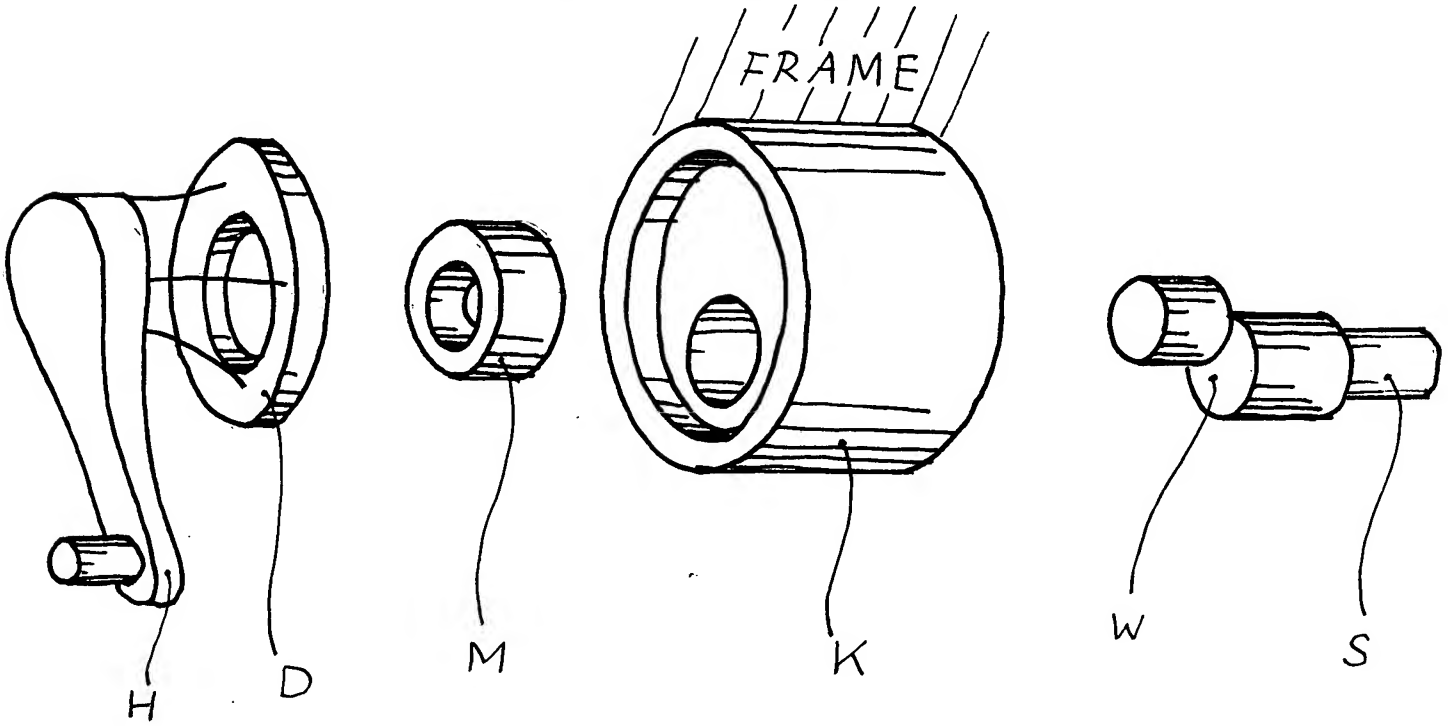
I just take the mechanism as shown in paragraph c above, and subsequently convert it into suspension units as shown in figures 1-3 (suspension units as shown in figures 4 and 6 are also discussed below, however I omit figures in interests of brevity).

d. The suspension unit as shown in Fig. 1 (with minor changes not being referred to in the patent claims) is obtained by fastening a vehicle wheel arm H to the main pivot W1 of the shaft W, coupling rigidly one end of a torsion spring S with the disc D (the other end of the torsion spring is anchored in the vehicle frame) and fitting the body K with a flange Z, through which the whole suspension unit is fastened to the vehicle frame:



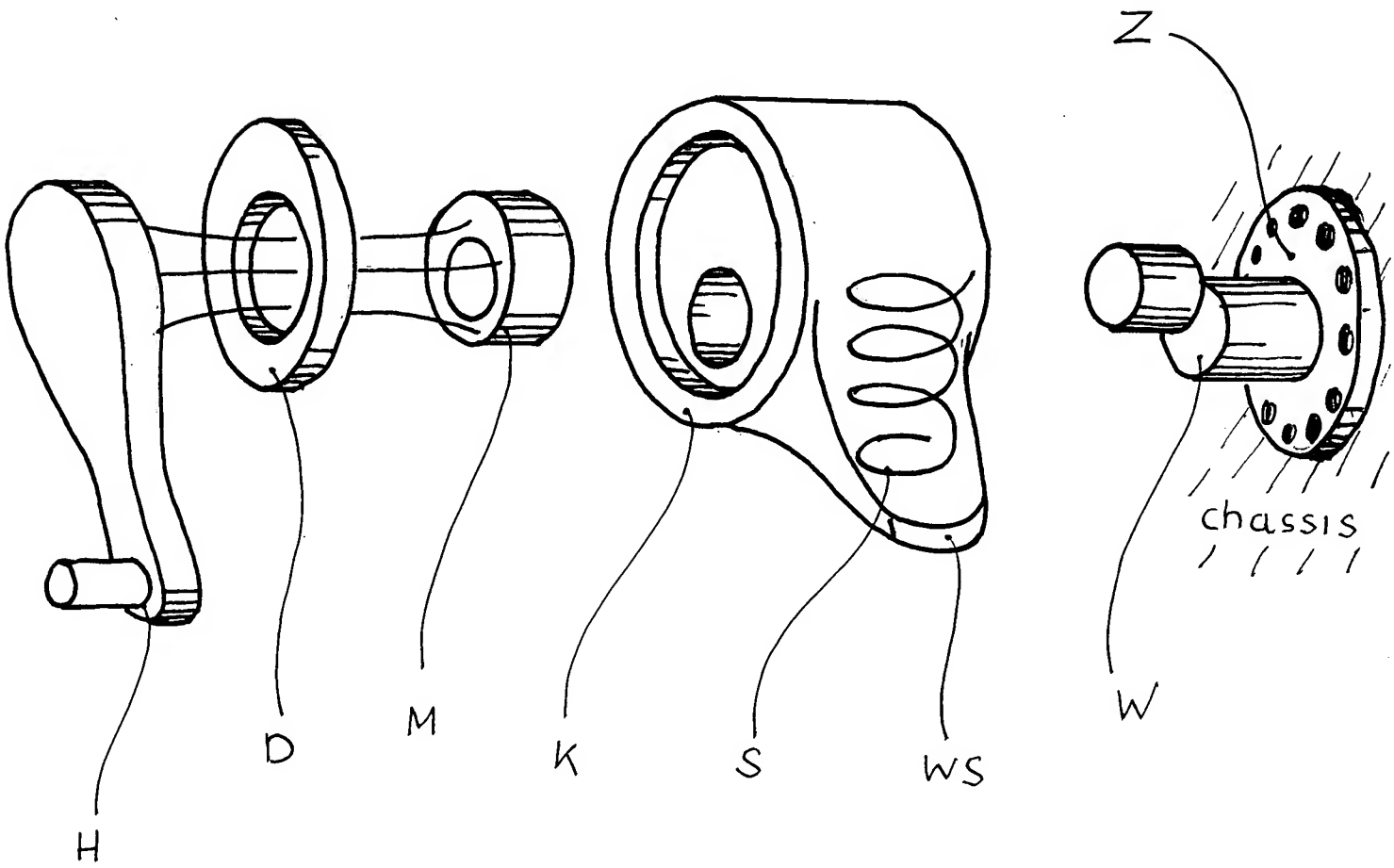
Thus this suspension unit comprises a four-link mechanism, which has the distinctive feature defined in generic claim 11 (new), and therefore the suspension unit is covered by said generic claim 11 (new). Moreover the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other, and therefore the suspension has the distinctive feature defined in the claim 12 (new). Moreover the claim 14 (new) is readable on this species of my suspension system.

e. The suspension unit as shown in Fig. 2 (with minor changes not being referred to in the patent claims) is obtained from the mechanism as shown in paragraph c above by fastening one end of a torsion spring S to the main pivot W1 of the shaft W (the other end of the torsion spring is anchored in a vehicle frame), coupling rigidly the vehicle wheel arm with the disc D and fitting the body K with a flange Z, through which the whole suspension unit is fastened to the vehicle frame:



Thus this suspension unit comprises a four-link mechanism, which has the distinctive feature defined in generic claim 11 (new), and therefore the suspension unit is covered by said generic claim 11 (new). Moreover the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other, and therefore the suspension has the distinctive feature defined in the claim 12 (new). Moreover the claim 15 is readable on this species of my vehicle suspension system.

f. The suspension unit as shown in Fig. 3 (with minor changes not being referred to in the patent claims) is obtained from the mechanism as shown in paragraph c above by fastening a flange Z to the shaft W (the whole suspension unit is fastened to a vehicle (e.g. a tank) chassis through said flange Z), fitting the body K with a bracket WS supporting a coil spring S (the other end of the spring is anchored in the vehicle chassis or coupled with the shaft W), and coupling rigidly the vehicle wheel arm H with the intermediate eccentric M:



Thus this suspension unit comprises a four-link mechanism, which has the distinctive feature defined in generic claim 11 (new), and therefore the suspension unit is covered by said generic claim 11 (new). Moreover the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other, and therefore the suspension has the distinctive feature defined in the claim 12 (new). Moreover the claim 16 (new) is readable on this species of my vehicle suspension system.

g. The suspension unit as shown in Fig. 4 (again with minor changes not being referred to in the patent claims) is obtained by taking two copies of the mechanism as described in the paragraph c above, fitting the body K of both the mechanisms with a flange Z (through which the suspension unit is fastened to a vehicle frame), coupling rigidly an arm of one road wheel with the shaft W of one of the suspension mechanisms, coupling rigidly an arm of the other road wheel with the shaft W of the other suspension mechanism, and coupling one end of an U-shaped torsion spring with the intermediate eccentric M of one of the suspension mechanisms and coupling the other end of said torsion spring with the intermediate eccentric M of the other mechanism of the suspension unit. Therefore the generic claim 11 (new) and claims 12 (new) and 17 (new) are readable on this species of my vehicle suspension system.

h. The suspension unit as shown in figure 6 repeats the general scheme above: It is obtained from the mechanism described in paragraph c above by coupling rigidly a forked vehicle wheel arm H with the shaft W, fitting the disc D with a bracket T supporting a coil spring, and fitting the body K (now made in four pieces to facilitate assembly/disassembly of the suspension unit) with a flange, through which the suspension unit is attached to the vehicle frame. Therefore the generic claim 11 (new) and claims 12 (new) and 14 (new) are readable on this species of my vehicle suspension system (precisely the same claims as in the case of the species shown in the figure 1).

How to get a flat mechanism used in the species of my vehicle suspension system as shown in figure 7?

The vehicle suspension unit as shown in figure 7 uses a variant of the mechanism (K, M, W, D) as described in paragraphs a, b and c above, namely the variant obtained as the length of the bar D (see figure a above) tends to infinity. In this case the external diameter of the disc D (see figures b and c above) also tends to infinity, the kinetic couple D-K becomes a sliding one, while all other kinetic couples remain rotational ones, and the disc D assumes the form of a slider, **while two links of the mechanism (namely W and M) retain the form of eccentric.**

This form of the four-link mechanism is alluded to in the specific part of the generic claim 18 (new).

THEREFORE ALL THE SPECIES OF MY VEHICLE SUSPENSION SYSTEM SHOWN IN FIGURES 1-4, 6 AND 7 FORM A SINGLE GENERAL INVENTIVE CONCEPT.

(Below I prove that all the species shown in the figures 1-7 -including 5- form a single general inventive concept).

The suspension u[redacted]as shown in figure 7 uses a specific form of the four-link mechanism as described above (its two links W and M2 (and also M1 and M4) are made in the form of an eccentric). To be more precise the suspension unit comprises three mechanisms of this type, namely (K, M2, W, D2), (K, M1, W, D1) and (K, M3, W, D3), which have common links K and W (and the three mechanisms have suitably chosen geometry; in particular the mechanisms (K, M1, W, D1) and (K, M3, W, D3) have precisely the same geometry and thus precisely the same kinetics, and therefore they form a single mechanism of the kind described above with doubled intermediate eccentric M). A vehicle axle is coupled rigidly with the link D2, a leaf spring is coupled rigidly with the links D1 and D2, and the whole suspension unit is fastened to the vehicle frame through the link K.

Therefore the generic claim 18 (new) and the claim 19 (new) are readable on the species of my suspension unit as shown in figure 7.

How to get spatial mechanisms as used in my vehicle suspension?

The present discussion relates to the species of my vehicle suspension system shown in figure 5 and alluded to in the generic claim 11 (new) and the claim 13 (new) (and also claim 14 (new)).

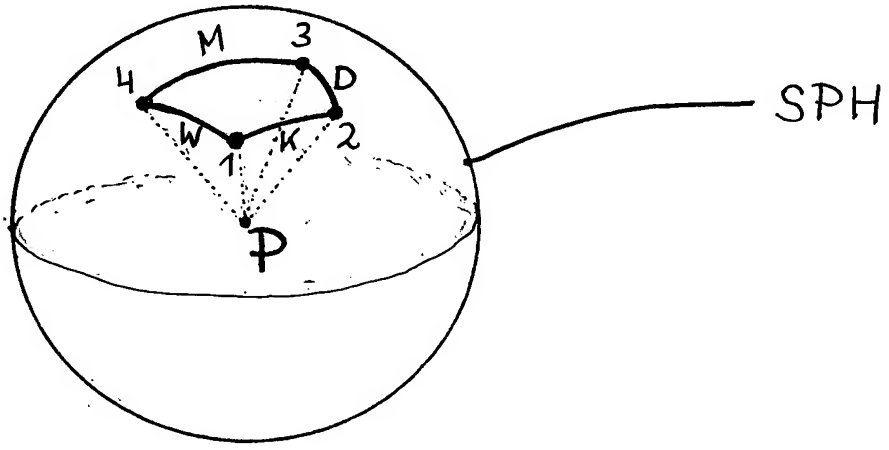
I apply to a spherical four bar linkage a procedure analogous to that described above.

In fact the procedure as described above applied to flat mechanisms is a special variant of the present procedure as radius of the sphere tends to infinity.

(Although, from the mathematical point of view, the flat mechanisms are just a special case of the spatial ones, in my patent specification they are treated separately, as they differ from the spatial mechanisms in a technically significant manner.)

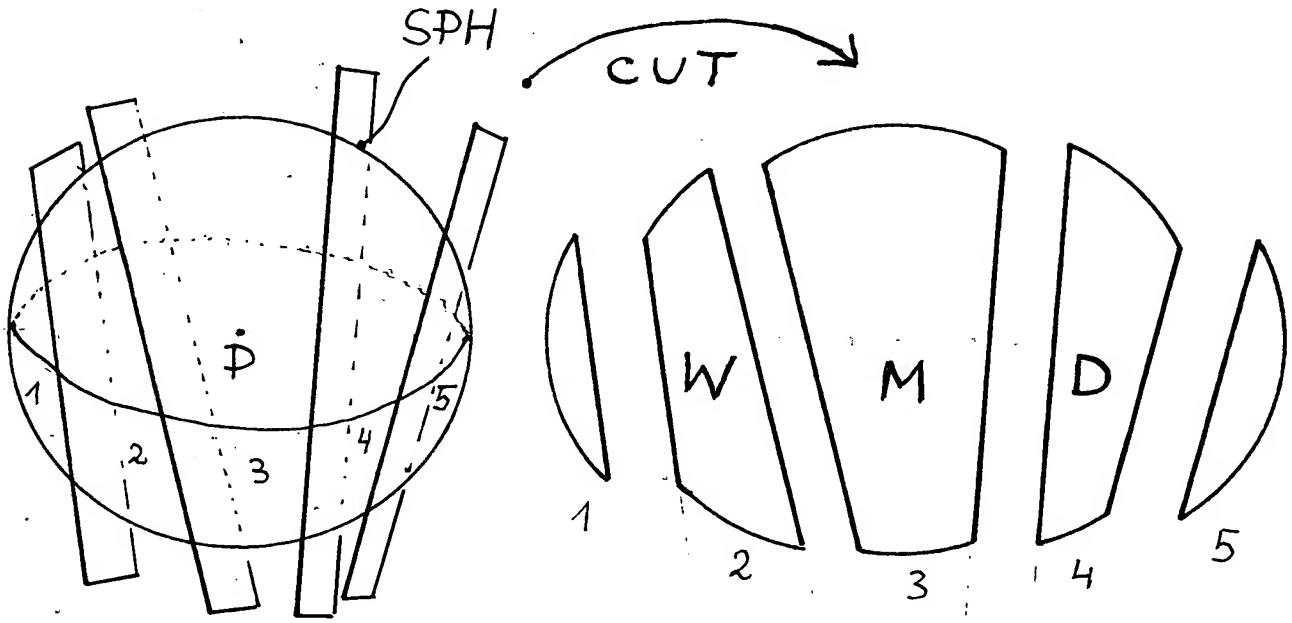
THEREFORE MY INVENTION OF THE VEHICLE SUSPENSION SYSTEM IS BASED ON A SINGLE INVENTIVE CONCEPT.

i. Start with the ordinary spherical four bar linkage placed on a sphere SPH of radius R with the center at a point P:



j. Cut the sphere SPH into five pieces 1,2,3,4,5 along four suitably chosen planes. In this way we get five elements 1-5, three of which (namely 2,3,4) **assume the form of**

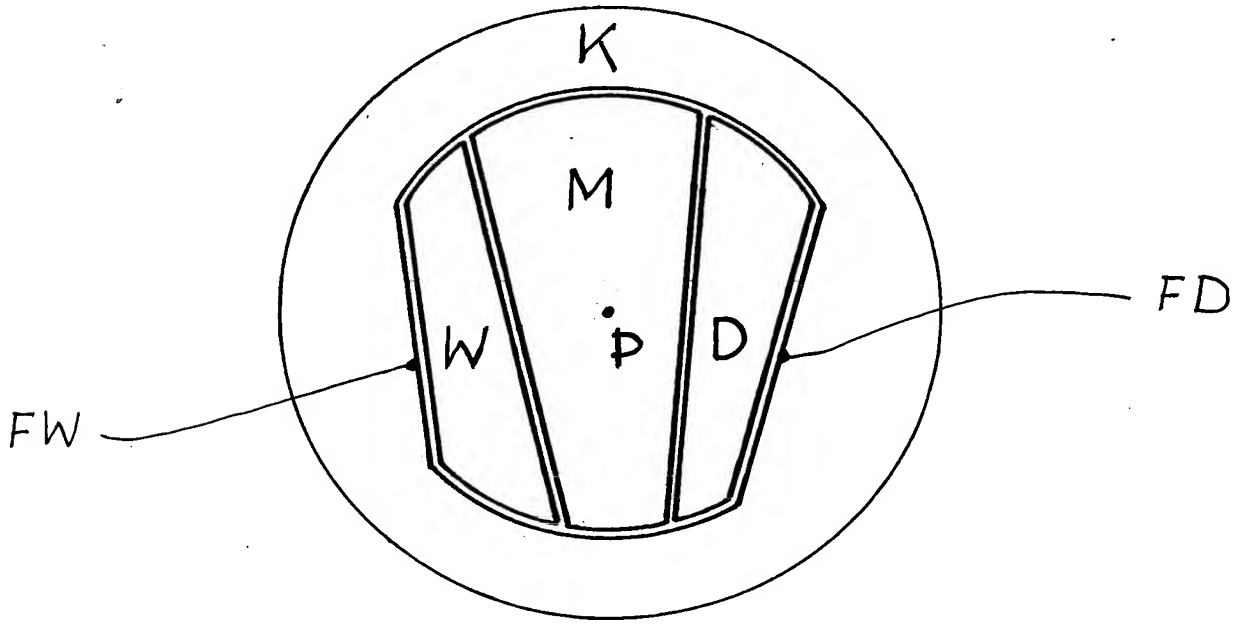
a spatial eccentric. The elements 2 and 4 are labeled W and D respectively, while the central element 3 is labeled M:



k. Take another element K with spherical bore chamber of radius R with two suitably chosen flat surfaces FW and FD, and put the elements W, M and D inside of said spherical bore chamber as shown in the picture below.

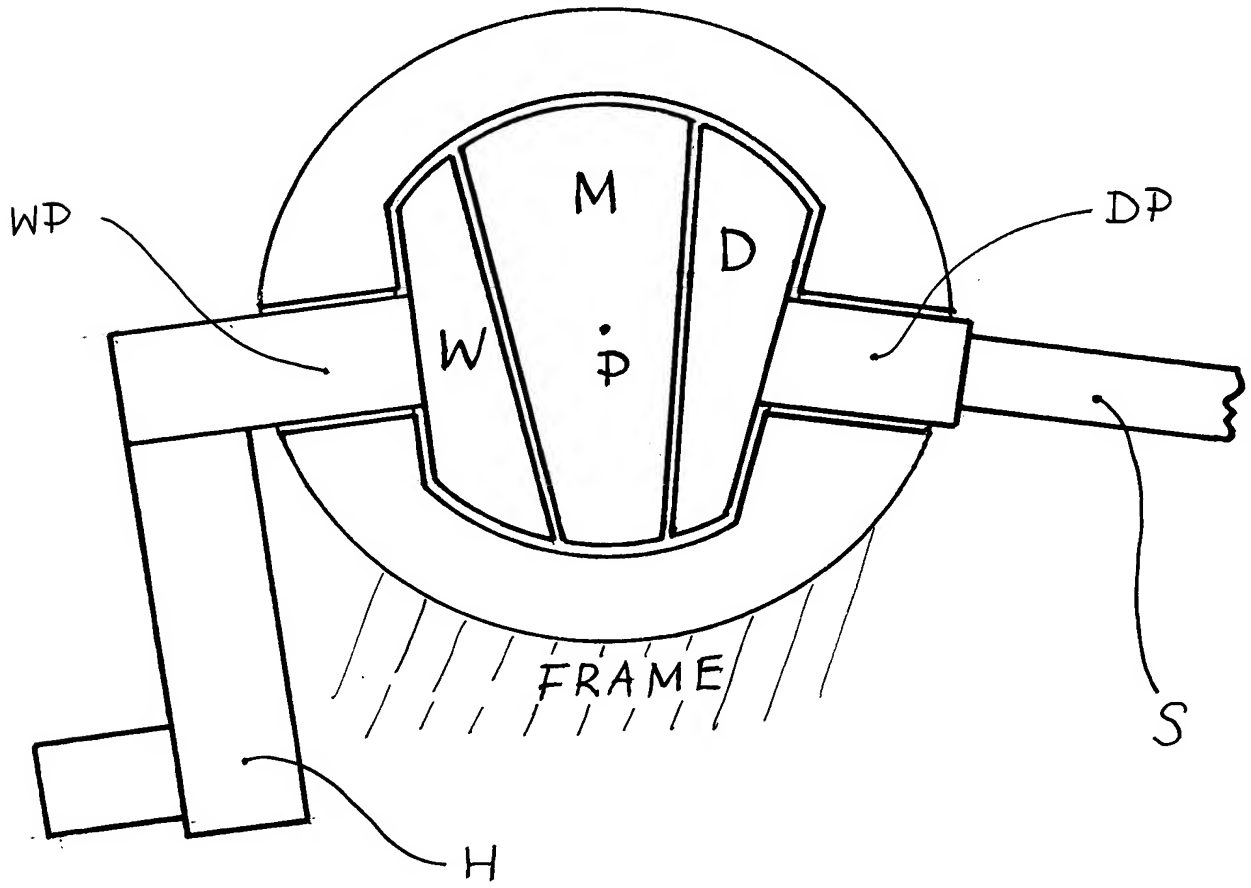
In this way I get a four-link mechanism (K, M, W, D) with kinetics of the ordinary four bar spherical linkage as shown in paragraph i above (this is an elementary but non-trivial mathematical observation due to myself), and which has three links W, M and D made in the form of a spatial eccentric.

This is precisely the kind of four-link mechanism, which is alluded to in the specific part of the generic claim 11 (new) and in the specific claim 13 (new) (the axes of rotation of all the kinetic pairs of the mechanism intersect at a precisely one point P, namely the center of the sphere SPH).



How do the mechanisms of this kind enter my vehicle suspension system?

l. Take a mechanism as described in paragraph k above and equip both the links W and D with pins WP and DP. Equip the link K with a flange Z. Fasten a vehicle wheel arm H to the link W (through the pin WP) and fasten a spring S (e.g. a torsion spring) to the link D (through the pin DP). Attach the suspension unit to the vehicle frame through the flange Z. In this way we get a vehicle suspension unit as shown in the **figure 5** (with minor changes not being alluded to in the patent claims; in particular to get precisely the mechanism of the suspension unit 5 some of the planes, along which we cut the sphere SPH should be perpendicular).



Therefore the generic patent claim 11 (new) and patent claims 13 (new) and 14 (new) are readable on the species of my vehicle suspension shown in the figure 5.

The procedure described in paragraphs i-l above and the concept to apply mechanisms obtained in this way to vehicle suspension is the crucial inventive step and it is certainly innovative and non-trivial.

3. Basing on the detailed discussion above (and the patent specification and patent claims 11-19 (new)) **I conclude:**

A. **THE EXISTENCE OF A FLAT OR SPATIAL FOUR-LINK MECHANISM (FOUR BAR LINKAGE) AS DESCRIBED IN THE SPECIFIC PART OF THE GENERIC CLAIM 11 (NEW) ("...CHARACTERISED IN THAT THREE OF SAID LINKS ARE MADE IN THE FORM OF AN ECCENTRIC...") AND ALSO IN CLAIMS 12 (NEW) AND 13 (NEW) IS A HIGHLY NON-TRIVIAL FACT.**

APPLICATION OF MECHANISMS OF THIS TYPE IN A VEHICLE SUSPENSION IS A NEW NON-TRIVIAL INVENTIVE CONCEPT.

THEREFORE EVEN THE EXISTENCE OF A VEHICLE SUSPENSION AS DESCRIBED IN THE CLAIMS 11-13 IS A NON-TRIVIAL NEW FACT.

THEREFORE:

B. **THERE IS NO LACK OF UNITY OF INVENTION:**

My vehicle suspension system is based on a single NON-TRIVIAL inventive concept disclosed in the generic claim 11 (new) readable on all the species labeled by yourselves A, B, C, D and E, which therefore form a single general inventive concept.

Therefore your claim that the application lack unity of invention is false and should be traversed.

C. **ALL THE SPECIES A-E DO HAVE THE SAME SPECIAL INNOVATIVE (NON-OBVIOUS) TECHNICAL FEATURE:**

A FOUR-LINK MECHANISM OF ALL OF THESE SPECIES OF MY VEHICLE SUSPENSION HAS A SPECIFIC FORM AS DESCRIBED ABOVE AND AS DESCRIBED IN THE PATENT CLAIMS 11-13 (NEW) AND 18 (NEW).

In particular the claimed specific technical feature of all these species IS OBVIOUSLY NOT just the inclusion of an eccentric connection.

Therefore considering the species A-E different inventive concepts is unjustifiable and invalid.

In particular your division of my suspension system into separate species A-E is based on technical features (torsion spring, rotary arm, lever/coil arrangement etc) that have NOTHING TO DO with my inventive concept and therefore are completely inessential from the point of view of the inventive significance of my vehicle suspension system.

Therefore the requirement to elect the invention to be examined is unjustifiable and should be traversed.

4. IN ORDER TO FULFILL THE REQUIREMENTS FORMULATED IN THE "DETAILED ACTION":

A. I elect the species A to which the claims 11-19 (new) should be restricted if no generic claim is finally held to be allowable.

B. I identify the claims readable on the elected species:

The generic claim 11 (new), the claim 12 (new), the claim 14 (new) and the claim 15 (new) are all readable on the elected species A.

Mieczław Olędzki

Wieslaw Julian Olędzki
Ul. Lipowa 18A m.2
15-427 Białystok
POLAND

Białystok, 7/03/2002

OFFICE OF INITIAL PATENT EXAMINATION'S
CUSTOMER SERVICE CENTER
UNITED STATES PATENT AND TRADEMARK
OFFICE
WASHINGTON D.C. 20231
USA

Dear Sirs

I would like to correct the following minor error observed on the Filing Receipt (Confirmation No. 1910) concerning my patent application "Vehicle suspension system, particularly for road and off-road vehicles", PCT/PL00/00030, I.A. Filing Date 04/19/2000, **US Application Number 10/019,083, Filing Date 12/26/2001, Group Art Unit 3611:**

The total number of claims is 10 and the number of independent claims is 1 **in the patent application as originally filed.** Now, after amendments have been made according to PCT Rule 66.3, **the total number of claims is 9 and the number of independent claims is 2 (namely the claims No. 1 and 8).** The amendments have been communicated by the International Bureau to all the Elected Offices together with the International Preliminary Examination Report.

Respectfully submitted

Wiesław Julian Olędzki

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

OLEDZKI WIESLAW JULIAN
UL.LIPOWA 18A M2
15-427 BIALYSTOK
POLOGNE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	09.10.2001
Applicant's or agent's file reference ./.	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/PL00/00030	19/04/2000	12/07/1999

Applicant
OLEDZKI, Wieslaw, Julian

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	BON, L Tel.+49 89 2399-2961

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
./.		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/PL00/00030	19/04/2000	12/07/1999
International Patent Classification (IPC) or national classification and IPC B60G17/02		
Applicant OLEDZKI, Wieslaw, Julian		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
02/10/2000	09.10.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Roberts, D Telephone No. +49 89 2399 8880

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/PL00/00030

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

3-9	as originally filed			
1,2	as received on	18/09/2001	with letter of	10/09/2001

Claims, No.:

1-9	as received on	18/09/2001	with letter of	10/09/2001

Drawings, sheets:

1/8-8/8	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-9
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

1. Reasoned Statement (V)

1.1 The present invention relates to a vehicle suspension system comprising a spring and a four-link mechanism and having a non-linear dependence of deformation of the spring on the vehicle wheel movement. Such a system corresponding to the preamble of claim 1 is known, for example, from WO-A-96/11815.

1.2 The object of the present invention to provide an improved suspension system having a compact, simple and robust structure able to cope with large loads.

1.3 The above object is achieved by means of the characterising features of claim 1, which are neither known from nor rendered obvious by the available prior art.

2. Certain Defects (VII)

2.1 The application contains the following obvious error (see Guidelines VI-7.14): The word "sliders" is missing in claim 9, line 4 between "corresponding" and "(D1)".

Vehicle suspension system, particularly for road and off-road vehicles

The present invention relates to a vehicle suspension system, particularly for road and off-road vehicles, such as trucks, buses and military vehicles, including tanks, and first of all for those vehicles whose weight and dynamical loads vary within a broad range during the operating process.

The main function of vehicle suspension is to reduce vibrations transferred to a vehicle body by vehicle wheels. The suspension is a set of elements connecting the vehicle wheels with the vehicle frame or body. Suspensions of automotive vehicles are fitted with steel springs such as leaf springs, coil springs, torsion bars, as well as solid rubber elements and pneumatic springs and hydro-pneumatic elements.

Leaf springs are made of elastic steel flat bars. The leaf spring, supported in the middle and loaded on both ends, is subject to deformation and simultaneously works against the forces of elasticity.

Coil springs are made of steel spring wire. They are lighter and easier to assemble than leaf springs but unable to transfer side forces, hence additional elements are necessary to hold the vehicle axle.

Torsion bars are steel springs made in the form of rod, tube or flat bar pack, one end of which is anchored e.g. in a vehicle frame while the other one is twisted by an arm of a vehicle wheel.

Pneumatic springs are built in the form of two or three-fold bellow manufactured of synthetic rubber reinforced with cord plait and tightened in metallic holders. Pneumatic springs work utilizing pressure of compressed air contained therein. They are used in buses and trucks as well as in off road vehicles. There are also hydro-pneumatic suspensions, in which the elastic medium is a compressed gas contained in a chamber.

Further compression of the gas results from the action of a piston, which follows the movement of a vehicle wheel.

The spring rate of steel springs is, in general, constant. Thus the damping characteristic of most prior-art vehicle suspension systems using such a spring is linear or nearly linear, which is their major disadvantage. Some of steel springs, e.g. coil springs, can be made progressive, however damping characteristic of vehicle suspension using such springs cannot be freely shaped and remains remarkably inferior to that of the air spring.

Some unconventional vehicle suspension systems providing non-linear damping characteristic and means for adjusting it are known from prior art. For example the International Publication WO-A-96 11815 of the International Application PCT/CA 95/00570 discloses a suspension system, in which the suspension arm rotates roller carriers, the rollers contained therein follows cam surfaces, which in turn force a spring supports to move axially and to compress the spring. The US patent No. 3,157,394 granted to Mr. O. K. Kelley in 1964 provides another example of suspension with a cam mechanism, a number of in turn actuated Belleville springs and non-linear non-differentiable characteristic. However non-linearity of damping characteristic of these suspensions is achieved by engaging springs through a cam mechanism; and means for adjusting the characteristic are shape of the cam, its position relative other elements of the suspension mechanism and nuts to regulate the initial length of the spring. Consequently, these suspensions are exceedingly complicated, of questionable durability and reliability, unable to cope with large loads, and means for adjusting damping characteristic of them are completely unsatisfactory.

A vehicle suspension, according to the present invention, is a purely mechanical device. Non-linearity of its damping characteristic and means for adjusting it to specific requirements is derived directly from the kinetic of the four bar mechanism. It contains no foreign ad hoc incorporated parts e.g. cams and features a compact and robust structure. In fact the structure of the mechanism of the suspension according to the present invention is the strongest possible as its moving parts occupy the whole internal space of its body. Thus it can cope with large loads and the capacity/weight ratio would be better than that of all kinds of known suspensions. It uses only standard springs, while it provides a damping characteristic, which betters that of hydro-pneumatic suspensions. Moreover the construction of the suspension, according to the invention, enables its characteristic to be freely chosen through the choice of the geometric parameters of the mechanisms comprised therein.

The manufacturing technology of the suspension according to the invention is simple and inexpensive. Moreover, the suspension provides the possibility of the relative position between elements connecting the suspension unit with vehicle wheels and a spring to be freely adjusted.

The invention solves the problem of constructing a vehicle suspension of non-linear characteristic using springs of linear characteristic. By non-linear characteristic is meant non-linear and differentiable dependence of suspension stiffness on vehicle axle flex.

The object of the invention is to provide a new type of vehicle suspension system destined for new vehicles, particularly for road and off-road ones, which also can be assembled in existing vehicles during overhauls, e.g. in tanks, and which improves substantially the shock absorption within the whole range of dynamical loads and vehicle weight variations.

The essence of the vehicle suspension system, according to the present invention, is that it comprises at least one flat or spatial four-link mechanism, three kinematic pairs of which are rotational ones, while the fourth one is either a rotational or a sliding one; and the two links of said mechanism are made in the form of eccentric and one link is made in the form of eccentric or slider, wherein one link of said mechanism is coupled with a vehicle wheel, another link of the mechanism is coupled with a spring, and the whole mechanism is fastened to a vehicle frame through yet another link, to obtain a non-linear dependence of deformation of the spring on an axle flex.

A good result is obtained when said suspension system, as four links of its mechanism, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric; the latter being coupled rotationally with a disc, while the shaft and the disc pivot directly in a mechanism body. The body is fastened to a vehicle frame. The shaft, in turn, is coupled rigidly with a vehicle wheel arm, and the disc is coupled with one end of a spring, the other end of which is fastened to the body of the mechanism or directly to the vehicle frame. In this arrangement, the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other.

A good result is also obtained when the suspension system, as its four links, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric which, in turn, is coupled rotationally with a disc, while the shaft and the disc pivot directly in a mechanism body, the latter being fastened to a vehicle frame. Besides, the disc is coupled rigidly with a vehicle wheel arm, and the shaft is coupled with one end of a spring the other end of which is fastened to the body or directly to the vehicle frame. In this arrangement the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other.

Amended sheet 2.

What I claim is:

1. A vehicle suspension system comprising a spring and at least one flat or spatial four-link mechanism (K, M, W, D), at least three kinematic pairs of which are rotational ones, wherein one of the links of said mechanism is coupled with a vehicle wheel, another of said links is coupled with a spring (S), and the whole mechanism is fastened to a vehicle frame through yet another link of said mechanism, to obtain non-linear dependence of deformation of the spring on the vehicle wheel flex, characterized in that, three of said links are made in the form of an eccentric, whereby said four-link mechanism (K, M, W, D) comprises a shaft (W) fitted with an eccentric (MW), the latter being coupled rotationally with an intermediate eccentric (M), the latter being coupled rotationally with a disc (D), wherein the shaft (W) and the disc (D) pivot directly in a body (K).

2. A vehicle suspension system according to claim 1, characterized in that the axes of rotation of all the kinematic pairs of said suspension mechanism are parallel to each other.

3. A vehicle suspension system according to claim 1, characterized in that the axes of rotation of all the kinematic pairs of said suspension mechanism intersect at a precisely one point P, to obtain a required position of the spring relative to the vehicle wheel.

4. A vehicle suspension system according to claim 2 or claim 3, characterized by said body (K) being fastened to a vehicle frame, and said shaft (W) being coupled rigidly with a wheel arm, and wherein the disc (D) is coupled with one end of the spring (S) the other end of which is fixed to the body (K) or directly to the vehicle frame.

5. A vehicle suspension system according to claim 2 or claim 3, characterized by said body (K) being fastened to a vehicle frame, and said disc (D) being coupled rigidly with a wheel arm, and said shaft (W) being coupled with one end of a spring (S) the other end of which is fixed to the body (K) or directly to the vehicle frame.

6. A vehicle suspension system according to claim 2 or claim 3, characterized by said shaft (W) being fastened to a vehicle frame through the flange (Z), said intermediate eccentric (M) being coupled rigidly with a vehicle wheel arm (H), and said body (K) being coupled rigidly with one end of a spring (S) the other end of which is fixed to the shaft (W) or directly to the vehicle frame.

7. A vehicle suspension system according to claim 2 or claim 3, characterized by said body (K) being fastened to a vehicle frame, said shaft (W) being coupled rigidly with a vehicle wheel arm, and the intermediate eccentric (M) being coupled with one end of an U-shaped torsion bar the other end of which is fixed to the intermediate eccentric of an analogous mechanism of a suspension of the other wheel.

8. A vehicle suspension system comprising a spring and a least one flat or spatial four-link mechanism (K, M, W, D), three kinematic pairs of which are rotational ones and one of the links being made in the form of a slider such that the fourth kinematic pair is a sliding one, wherein one of the links of said mechanism is coupled with a vehicle wheel, another of said links is coupled with a spring (S), and the whole mechanism is fastened to a vehicle frame through yet another link of said mechanism, to obtain non-linear dependence of deformation of the spring on the vehicle wheel flex, characterized in that, two of said links are made in the form of an eccentric, whereby said four-link mechanism comprises a shaft (W) fitted with an eccentric (MW), the latter being coupled rotationally with an intermediate eccentric (M), the latter being coupled rotationally with a slider (D), wherein the shaft (W) pivots directly in a body (K) and the slider is slidingly fitted in the body (K).

9. A vehicle suspension system according to claim 8, characterized by a shaft (W) fitted with three eccentrics (MW1), (MW2) and (MW3), the latter being coupled rotationally with corresponding intermediate eccentrics (M1), (M2), and (M3), the latter being coupled rotationally with corresponding (D1), (D2) and (D3), wherein the sliders (D1), (D2) and (D3) are slidingly fitted in the body (K), said body (K) being fastened to a vehicle frame, the slider (D2) being coupled with a vehicle axle and the sliders (D1) and (D2) being coupled with a spring, which, in turn, is fastened to the vehicle frame.